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Baek

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(54) **BATTERY PACK WITH RIBS PROVIDED IN A CORNER OF THE BATTERY CASE**

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H01M 2/10 (2006.01)

(52) **U.S. Cl.**
CPC ***H01M 2/1022*** (2013.01); ***H01M 2/105*** (2013.01)

(58) **Field of Classification Search**
CPC H01M 2/105; H01M 2/1055
USPC 429/7, 99, 151, 159
See application file for complete search history.

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(57) **ABSTRACT**

A battery pack having a case configured to prevent deformation. The battery pack includes a plurality of bare cells, a circuit module electrically connected to the plurality of bare cells, and a case accommodating the plurality of bare cells and the circuit module. The case includes a first case having one side opened to accommodate the plurality of bare cells and the circuit module and a second case covering the opened one side of the first case. The first case has a first planar part that is a bottom surface on which the plurality of bare cells are mounted, and first case side parts bent from the first planar part and extending toward the second case. The first case has corners formed by connecting neighboring first case side parts. A first rib unit is formed at inside of at least one of the corners.

16 Claims, 9 Drawing Sheets

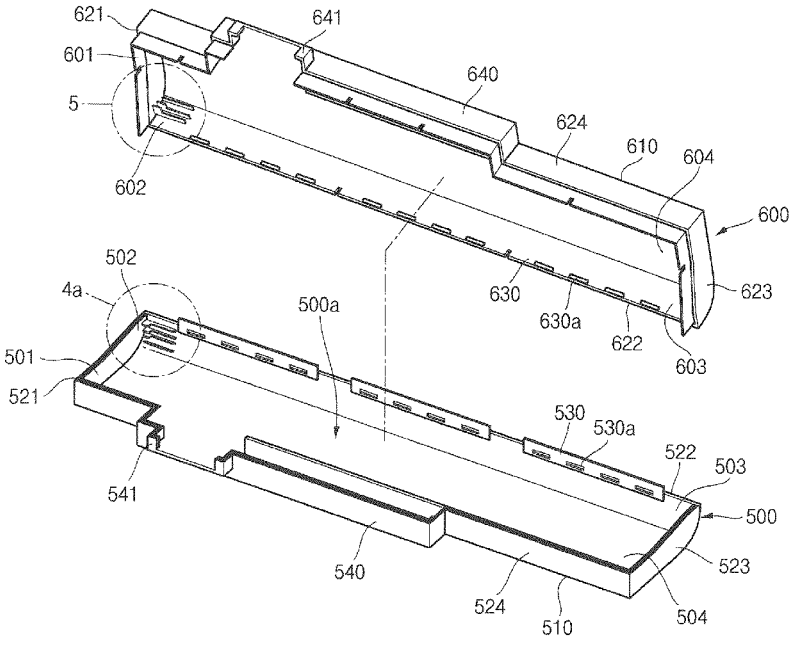


FIG. 1A

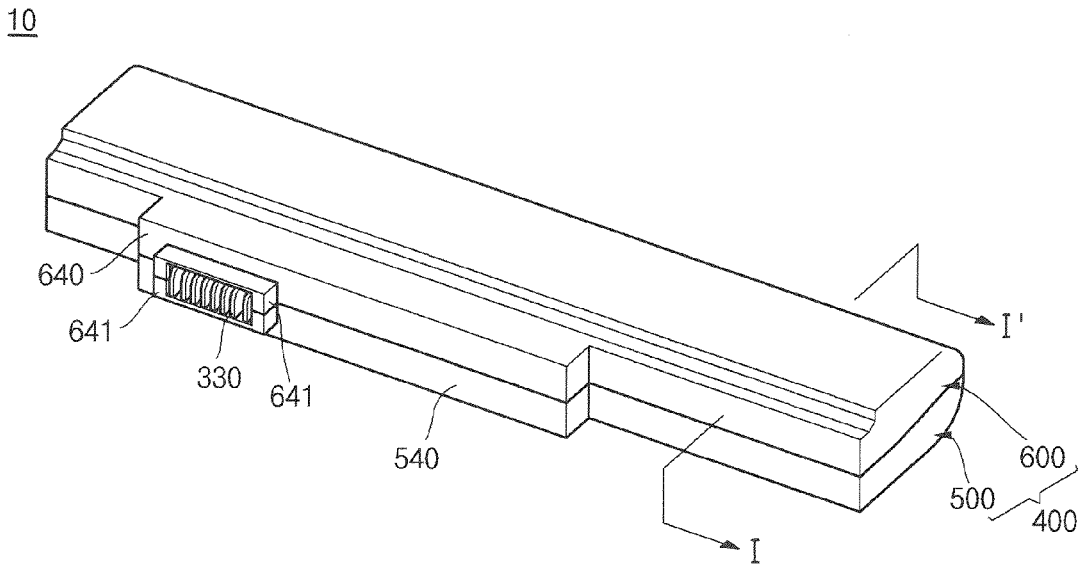

10
640
641
330
641
540
I'
I
600
500
400

FIG. 1B

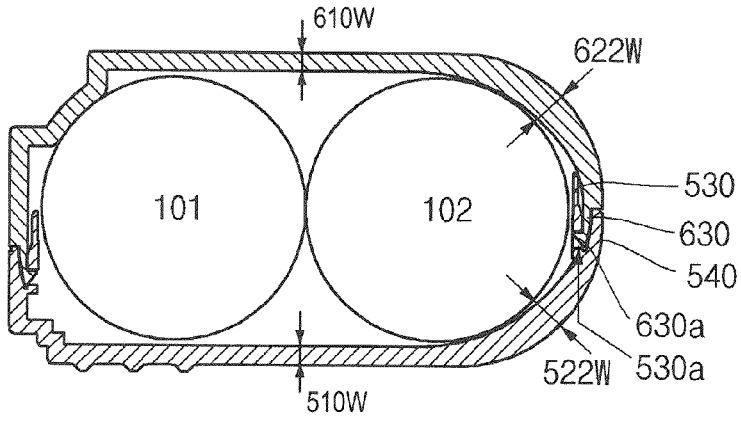

610W
622W
101
102
530
630
540
630a
530a
522W
510W

FIG. 2

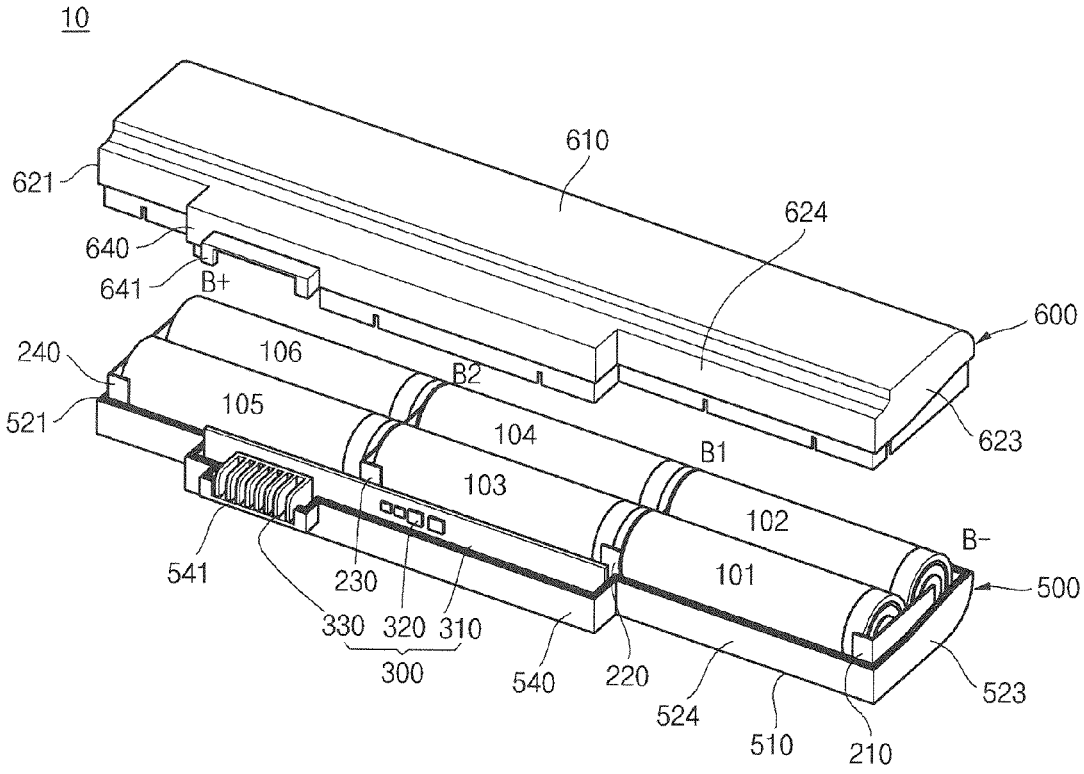

10
610
621
624
640
641
B+
600
240
106
B2
105
104
521
B1
623
103
102
B-
101
500
541
230
330
320
310
300
540
220
524
523
510
210

FIG. 3

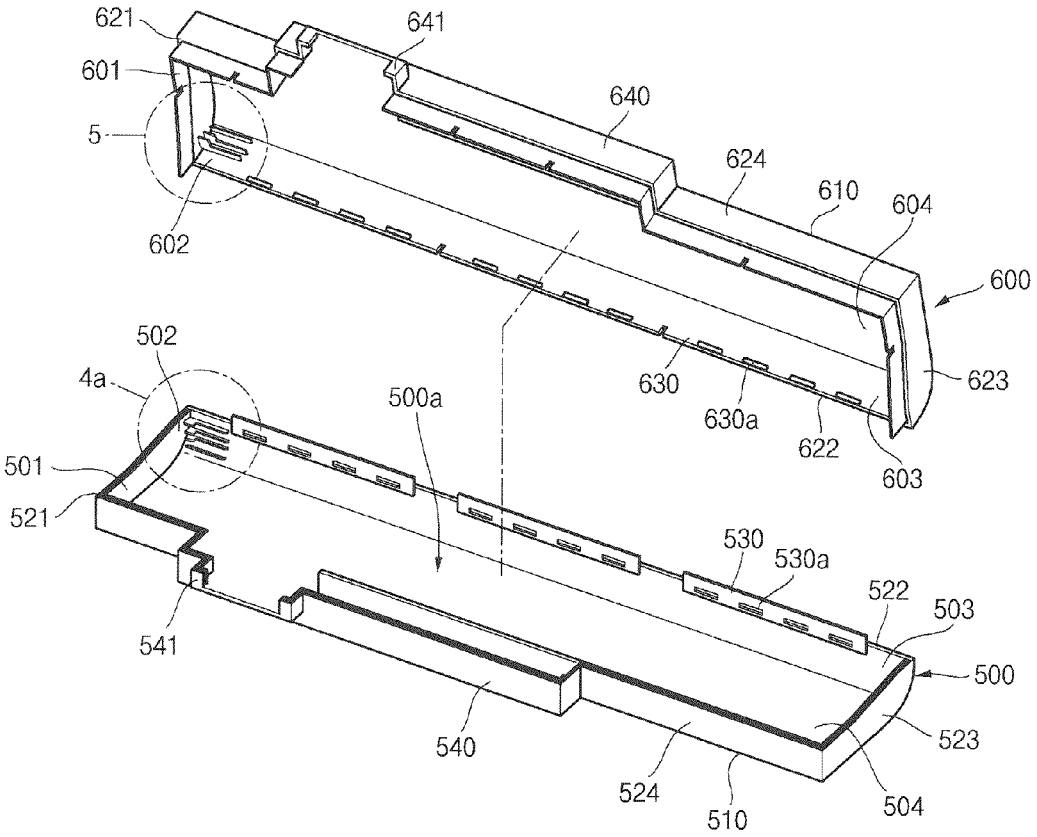

621
641
601
640
5
624
610
604
602
600
502
4a
623
500a
630
630a
622
603
501
521
530
530a
522
503
541
500
523
540
524
504
510

FIG. 4A

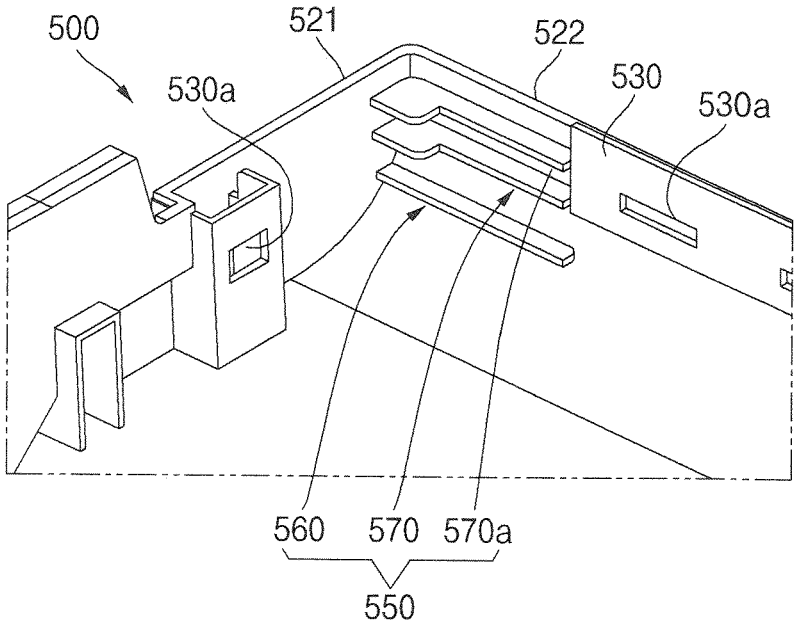


FIG. 4B

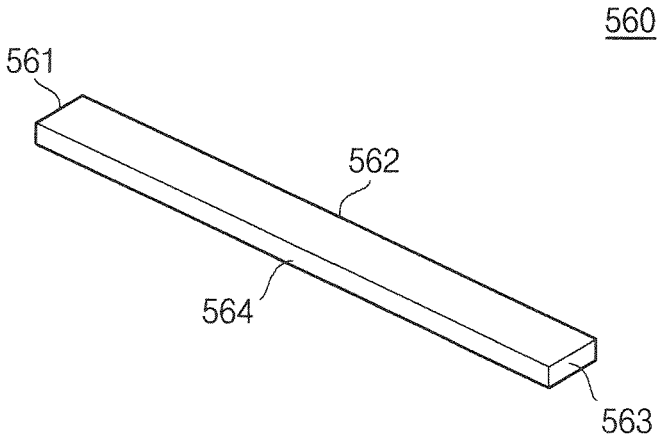


FIG. 4C

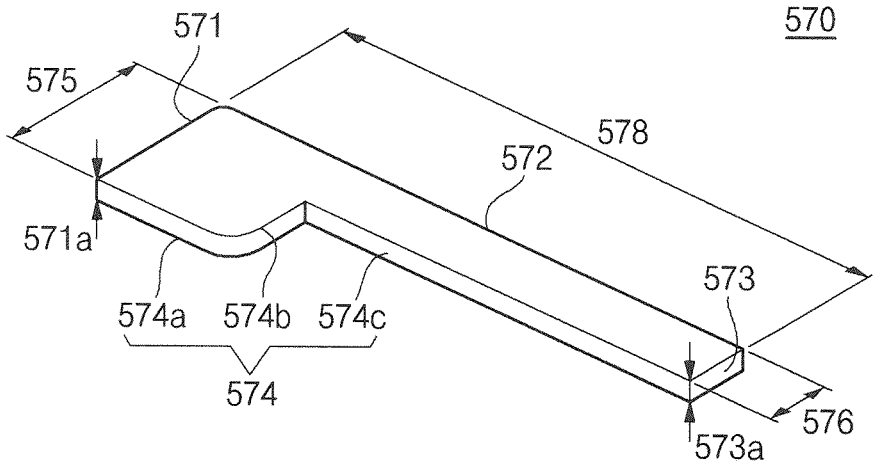

571
570
575
578
572
571a
573
574a
574b
574c
574
576
573a

FIG. 5

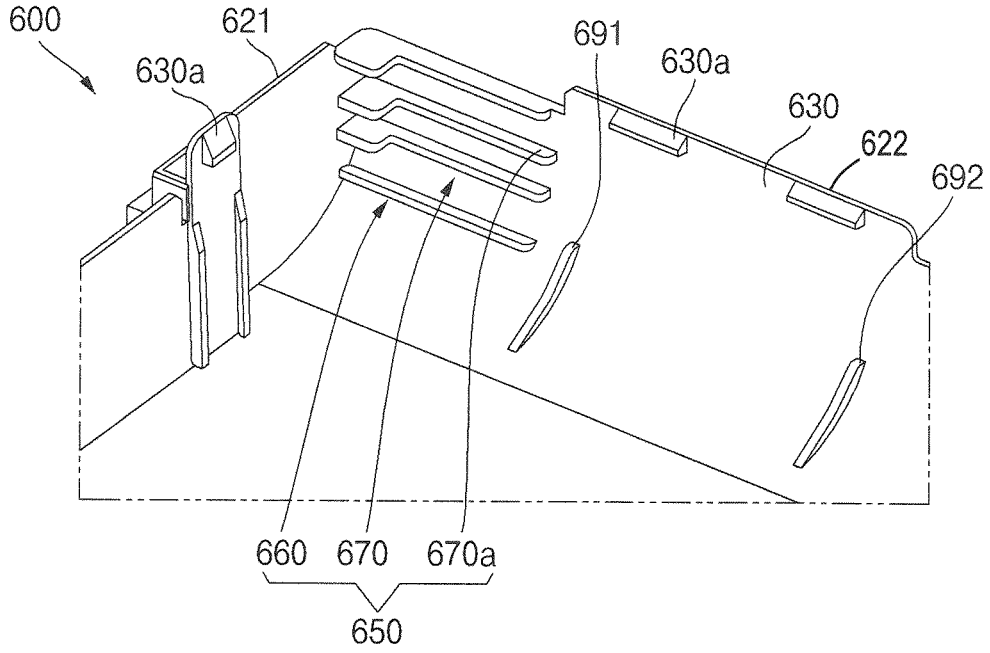

600
621
691
630a
630a
630
622
692
660
670
670a
650

FIG. 6A

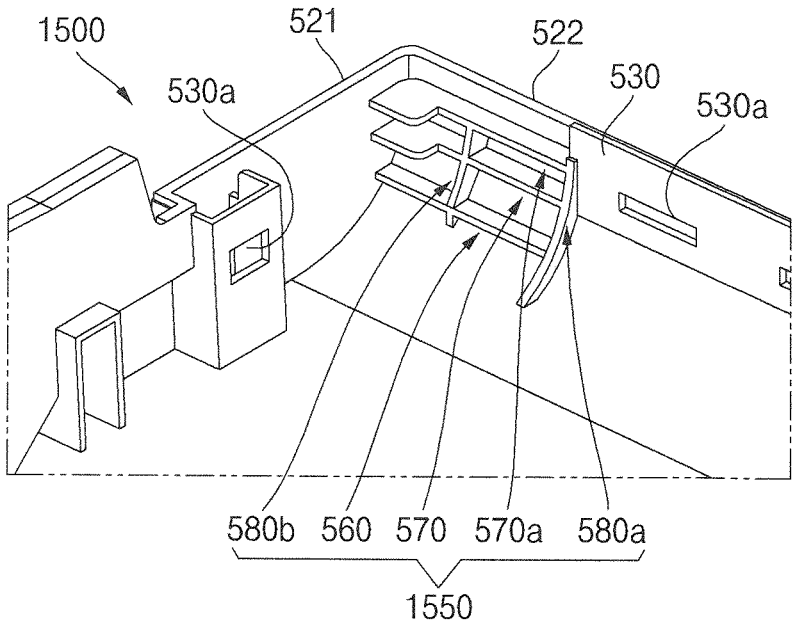

1500
521
522
530
530a
530a
580b
560
570
570a
580a
1550

FIG. 6B

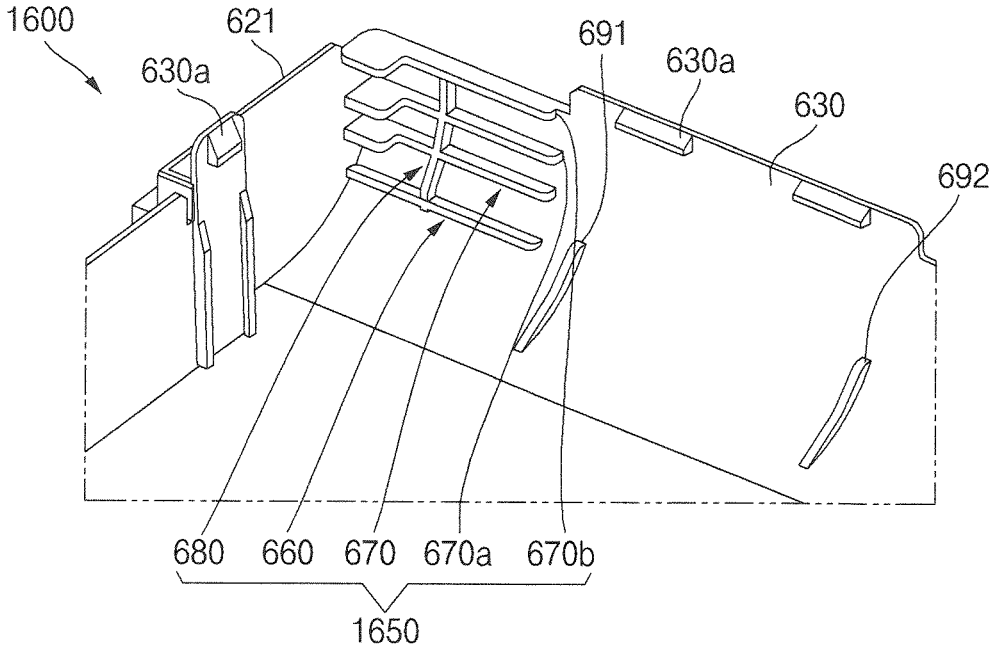

1600
621
691
630a
630a
630
692
680
660
670
670a
670b
1650

FIG. 7A

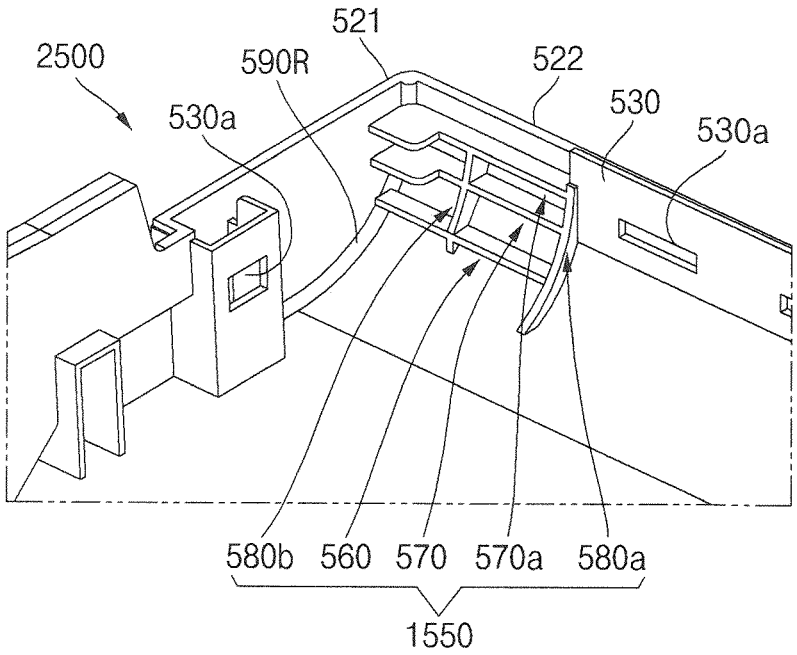

2500
590R
521
522
530
530a
530a
580b
560
570
570a
580a
1550

FIG. 7B

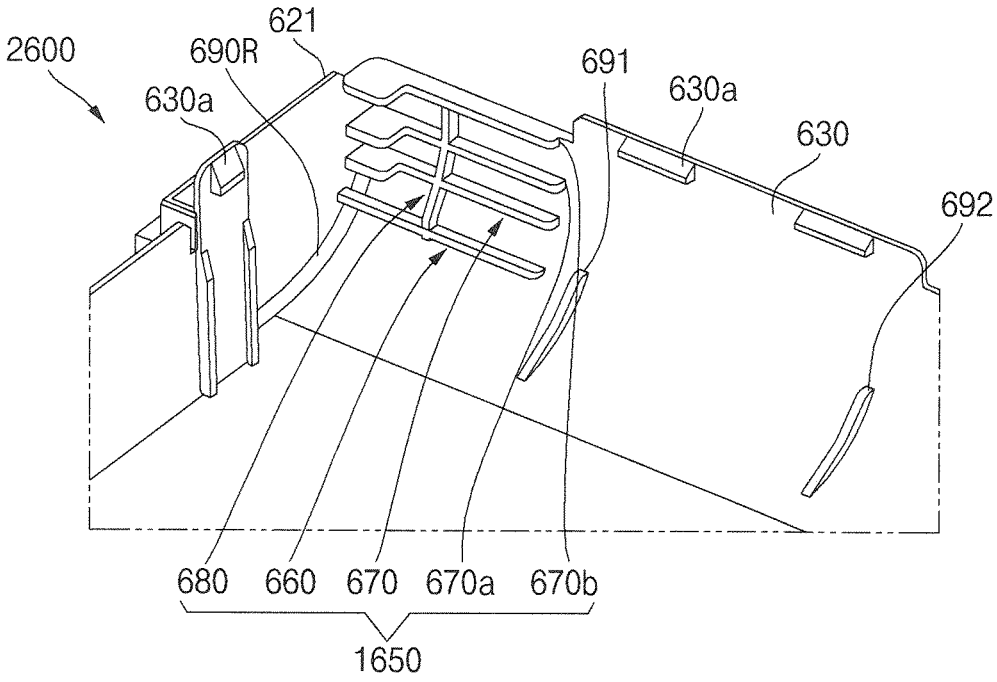

2600
690R
621
691
630a
630a
630
692
680
660
670
670a
670b
1650

FIG. 8

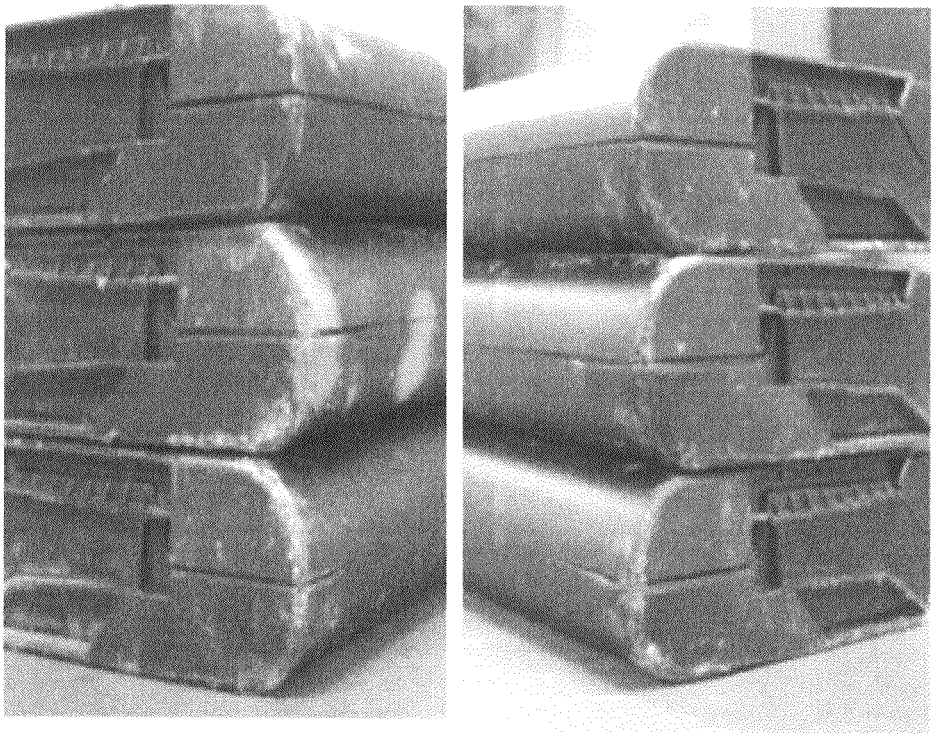
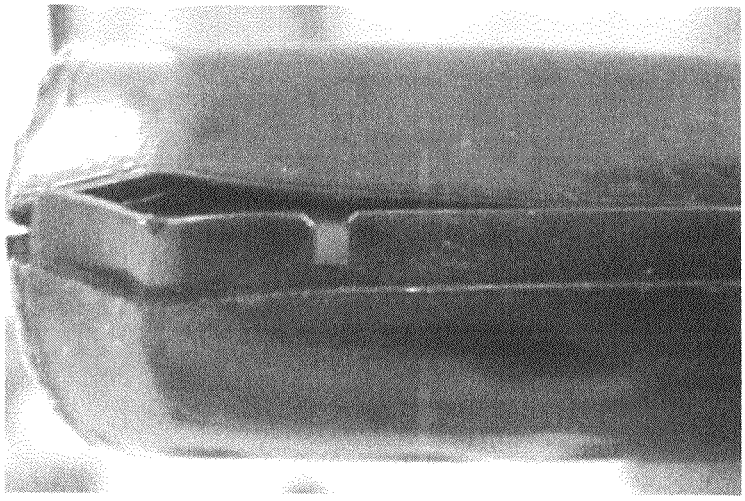


FIG. 9



BATTERY PACK WITH RIBS PROVIDED IN A CORNER OF THE BATTERY CASE

CLAIM OF PRIORITY

This application claims the benefit of Korean Patent Application No. 10-2012-0019947 filed on Feb. 27, 2012, the contents of which are incorporated herein by reference in their entirety.

BACKGROUND OF THE INVENTION

1. Field of the Invention

Aspects of the present invention relate to a battery pack.

2. Description of the Related Art

A secondary battery is formed by accommodating an electrode assembly formed by disposing a separator as an insulator between positive and negative electrode plates and an electrolyte in a case and sealing an opening of the case using a cap assembly having an electrode terminal.

Meanwhile, the secondary battery having only a unit battery (a single bare cell) may be packaged and used as a product according to the external device used. However, a plurality of unit batteries may be packaged into a pack to be commercially used. In this case, the plurality of unit batteries are mounted in the case, and the case consists of a top case and a bottom case. In general, a battery pack is formed by mounting the plurality of unit batteries in the bottom case and assembling the top case with the bottom case.

SUMMARY OF THE INVENTION

Aspects of the present invention provide an improved battery pack having a case, which can prevent the case from being deformed by improving a coupling force of the battery pack against external shocks.

According to aspects of the present invention, there is provided a battery pack including a plurality of bare cells, a circuit module electrically connected to the plurality of bare cells, and a case accommodating the plurality of bare cells and the circuit module. The case includes a first case having one side opened to accommodate the plurality of bare cells and the circuit module and a second case covering the opened one side of the first case. The first case has a first planar part that is a bottom surface on which the plurality of bare cells are mounted, and first case side parts bent from the first planar part and extending toward the second case. The first case has corners formed by connecting neighboring first case side parts, and a first rib unit is formed at inside of at least one of the corners.

The first rib unit may have a plurality of ribs connected to protrude from the inside of the corner. Each rib may be arranged to be spaced apart from a neighboring rib.

Each of the rib may be shaped of a plate and at least two side surfaces of the plate may be connected to the first case side parts at the corner.

Each of the ribs may have a first outer surface and a second outer surface connected to the first case side parts at the corner. The first outer surface and the second outer surface may have different lengths.

Each of the ribs may be shaped of a plate having a thickness greater at one end than at the other end, and the thicker one end of the plate may be connected to one of the first case side parts at the corner.

The first rib unit may further include a first reinforcement rib connecting at least two of the ribs.

The first case side part may further include a corner reinforcement unit formed at the inside of at least one corner where the neighboring side parts are connected to each other.

The second case may have a second planar part corresponding to top portions of the mounted bare cells and second case side parts bent from the second planar part and extending toward the first case. The second case may have corners formed by connecting the neighboring second case side parts to each other. A second rib unit may be formed at inside of at least one corner of the second case.

The second rib unit may be located to correspond to the first rib unit.

The second rib unit may include a plurality of ribs, each of the ribs is shaped of a plate, and at least two surfaces of the plate may be connected to and protrude from the inside of the corner.

The second rib unit may be disposed to correspond to the ribs of the first rib unit.

The second rib unit may further include a second reinforcement rib connecting at least two of the ribs.

The second rib unit may be positioned above the first rib unit, the first rib unit may include a first reinforcement rib connecting the plurality of ribs, the second rib unit may include a second reinforcement rib connecting the plurality of ribs, and the second reinforcement rib may be positioned on an imaginary line along which the first reinforcement rib extends toward the second case.

A sectional thickness of at least one of the second case side parts may be greater than a thickness of the second planar part.

A sectional thickness of at least one of the first case side parts may be greater than a thickness of the first planar part.

The first case may have a plurality of coupling grooves formed in at least one of the first case side parts, and the second case may have a plurality of coupling protrusions to be engaged with the coupling grooves.

As described, above, the battery pack constructed as the embodiment of the present invention includes a first rib unit and a second rib unit connected to protrude from the inside of each of corners of the case, thereby improving a coupling force of the battery pack against external shocks and preventing the case from being deformed due to the external shocks.

Additional aspects and/or advantages of the invention will be set forth in part in the description which follows and in part will be obvious from the description or may be learned by practice of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

The aspects, features and advantages of the present invention will be more apparent from the following detailed description in conjunction with the accompanying drawings, in which:

FIG. **1**A is oblique view of a battery pack constructed as an embodiment of in accordance with the principles the present invention;

FIG. **1**B is a vertical cross-sectional view of the battery pack taken along line of FIG. **1**;

FIG. **2** is an exploded oblique view of the battery pack shown in FIG. **1**;

FIG. **3** is an exploded oblique view of a case constructed as an embodiment in accordance with the principles of the present invention;

FIG. **4**A is an enlarged oblique view of portion '**4***a*' in FIG. **3**, illustrating a first rib unit constructed as an embodiment in accordance with the principles of the present invention;

FIG. **4**B is an oblique view of a rib constructed as an embodiment in accordance with the principles of the present invention;

FIG. **4**C is an oblique view of a rib constructed as another embodiment in accordance with the principles of the present invention;

FIG. **5** is an enlarged oblique view of portion '**5***a*' in FIG. **3**, illustrating a second rib unit shown in FIG. **3** constructed as an embodiment in accordance with the principles of the present invention;

FIG. **6**A is an oblique view corresponding to FIG. **4**A, illustrating a third rib unit constructed as another embodiment in accordance with the principles of the present invention;

FIG. **6**B is an oblique view corresponding to FIG. **5**, illustrating a fourth rib unit constructed as another embodiment in accordance with the principles of the present invention;

FIG. **7**A is an oblique view corresponding to FIG. **4**A, illustrating a first case constructed as still another embodiment in accordance with the principles of the present invention;

FIG. **7**B is an oblique view corresponding to FIG. **5**, illustrating a second case constructed as still another embodiment in accordance with the principles of the present invention;

FIG. **8** is a photograph illustrating a test result of external shocks applied to a battery pack constructed in accordance with the principles of the according to the present invention; and

FIG. **9** is a photograph illustrating a test result of external shocks applied to a battery pack constructed in accordance with a Comparative Example.

DETAILED DESCRIPTION OF THE INVENTION

Hereinafter, examples of embodiments of the invention will be described in detail with reference to the accompanying drawings such that they can easily be made and used by those skilled in the art.

FIG. **1**A is an oblique view of a battery pack constructed as an embodiment in accordance with the principles of the present invention. FIG. **1**B is a vertically cross-sectional view of the battery pack taken along line I-I' of FIG. **1**. FIG. **2** is an exploded oblique view of the battery pack shown in FIG. **1**. FIG. **3** is an exploded oblique view of a case constructed as an embodiment in accordance with the principles of the present invention.

Referring to FIGS. **1**A to **3**, the battery pack **10** constructed as the embodiment of the present invention includes a plurality of bare cells **101**, **102**, **103**, **104**, **105** and **106**, first to fourth lead plates **210**, **220**, **230** and **240**, a protection circuit module **300** and a case **400**. The case **400** may include a first case **500** and a second case **600**.

Each of the plurality of bare cells **101**, **102**, **103**, **104**, **105** and **106** includes an electrode assembly (not shown), a can accommodating the electrode assembly, and a cap assembly (not shown) coupled to a coupling hole of the can while the electrode assembly is accommodated in the can. Top and bottom surfaces of the plurality of bare cells are positive and negative electrode terminals, respectively, and may have different polarities. In the illustrated embodiment, first to sixth bare cells **101**, **102**, **103**, **104**, **105** and **106** are provided, and the first bare cell **101** and the second bare cell **102** are connected to each other in parallel, forming a first bare cell set. The third bare cell **103** and the fourth bare cell **104** are connected to each other in parallel, forming a second bare cell set. The fifth bare cell **105** and the sixth bare cell **106** are connected to each other in parallel, forming a third bare cell set. Here, the first to third bare cell sets are connected to each other in series. For the sake of convenient explanation, the aforementioned structure may be defined as a 3 series-2 parallel structure. While the 3 series-2 parallel structure is illustrated in one embodiment of the present invention, the invention is not limited, thereto as long as the number of bare cells is 2 or greater.

In FIG. **2**, B+ and B− indicate high current terminals corresponding to power supply units at opposite ends of the plurality of bare cells connected to each other in series/parallel. Specifically, B+ denotes a positive electrode power unit, that is, a highest potential terminal, and B− denotes a negative electrode power unit, that is, a lowest potential terminal. Therefore, the negative electrode terminal of the first bare cell set may be a lowest potential terminal B−, and the positive electrode terminal of the third bare cell set may be a highest potential terminal B+.

Among the first to fourth lead plates, the first lead plate **210** and the fourth lead plate **240** are respectively positioned at the negative electrode terminal B− of the first bare cell set and the positive electrode terminal B+ of the third bare cell set, thereby connecting the respective bare cell sets to each other in parallel. Here, the first lead plate **210** and the fourth lead plate **240** may have a rectangular planar structure. The first lead plate **210** is welded and electrically connected to the negative electrode terminal B− of the first bare cell set, and the fourth lead plate **240** is welded and electrically connected to the positive electrode terminal B+ of the third bare cell set. Each of the first lead plate **210** and the fourth lead plate **240** may be made of a highly electrically conductive metal such as copper, nickel or aluminum. The first lead plate **210** and the fourth lead plate **240** may be directly electrically connected to pads (not shown) of the protection circuit module **300**. Alternatively, the first lead plate **210** and the fourth lead plate **240** may be electrically connected to the pads of the protection circuit module **300** using separate tabs.

The second lead plate **220** and the third lead plate **230** are respectively positioned between the first bare cell set and the second bare cell set (B**1**) and between the second bare cell set and the third bare cell set (B**2**), thereby connecting the respective bare cell sets to each other in series and in parallel. Here, each of the second lead plate **220** and the third lead plate **230** may have a centrally bent portion. Therefore, the second lead plate **220** is welded and electrically connected to the positive electrode terminal of the first bare cell set and the negative electrode terminal of the second bare cell set, and the third lead plate **230** is welded and electrically connected to the positive electrode terminal of the second bare cell set and the negative electrode terminal of the third bare cell set. Each of the second lead plate **220** and the third lead plate **230** may be made of a highly electrically conductive metal such as copper, nickel or aluminum. The second lead plate **220** and the third lead plate **230** may be directly electrically connected to pads (not shown) of the protection circuit module **300**. Alternatively, the second lead plate **220** and the third lead plate **230** may be electrically connected to the pads of the protection circuit module **300** using separate tabs.

The protection circuit module **300** may include a board **310**, a protection circuit element **320**, a connector **330** and pads (not shown).

The board **310** may include a printed circuit board **310** having a substantially rectangular shape. A conductive metal pattern (not shown) is formed within the board **310** and may be connected to the protection circuit element **320**, the connector **330** and the pads.

The protection circuit element **320** is positioned on one surface of the board **310** facing the outside of the battery pack **10** and checks charge/discharge states of the plurality of bare

cells and battery information regarding the current, voltage, temperature and so on, thereby protecting the battery pack **10**.

The connector **330** is positioned on one surface of the board **310** facing the outside of the battery pack **10** and may be mounted on a mounting portion of the connector **330** of the first case **500**. The connector **330** may serve as an electric path connected to an external electric device. The pads are positioned on one surface of the board **310** facing the plurality of bare cells and may be electrically connected to the first to fourth lead plates **210**, **220**, **230** and **240**, respectively.

The case **400** includes a first case **500** and a second case **600**. The first case **500** has one side **500***a* opened to accommodate the plurality of bare cells plurality of bare cells **101**, **102**, **103**, **104**, **105** and **106**, the lead plates **210**, **220**, **230** and **240** and the protection circuit module **300**. The second case **600** covers the opened one side of the first case **500**. The first case **500** may be shaped of a rectangular box having an open top portion to receive the plurality of bare cells **101**, **102**, **103**, **104**, **105** and **106**. A first case protection circuit module mounting portion **540** designed to correspond in shape to the protection circuit module **300** may be formed at one side of the first case **500** to receive the protection circuit module **300**. A first case connector mounting portion **541** in which the connector **330** of the protection circuit module **300** is mounted may be formed in the first case protection circuit module mounting portion **540**.

The first case **500** has a first planar part **510** and first to fourth side parts **521**, **522**, **523** and **524**.

The first planar part **510** is a bottom surface on which the plurality of bare cells **101**, **102**, **103**, **104**, **105** and **106** are mounted. The first to fourth side parts **521**, **522**, **523** and **524** are bent from edges of the first planar part **510** and extend toward the second case **600**.

A sectional thickness **522**W of each of the first to fourth side parts **521**, **522**, **523** and **524** may be greater than a thickness **510**W of the first planar part **510**. Each of the first to fourth side parts **521**, **522**, **523** and **524** may include a first rib **530** having a plurality of coupling grooves **530***a*. That is to say, the coupling grooves **530***a* are formed on a first coupling surface of the first rib **530**. The first to fourth side parts **521**, **522**, **523** and **524** have corners formed by connecting neighboring side parts to each other. That is, the first case **500** has corners **501**, **502**, **503** and **504** at the positions where neighboring side parts **521**, **522**, **523** and **524** meet and form an angle. While four corners are formed in the first case **500** in the illustrated embodiment, aspects of the present invention are not limited thereto.

In the present invention, the first case **500** has four corners **501**, **502**, **503** and **504** and a first rib unit **550** is formed at the inside of each of the four corners. For example, corner **502** may be formed by connecting the first side part **521** and the second side part **522** to each other.

FIG. **4**A is an enlarged oblique view of portion '**4***a*' in FIG. **3**, illustrating a first rib unit constructed as an embodiment in accordance with the principles of the present invention. Referring to FIG. **4**A, the first rib unit **550** includes a plurality of ribs **560**, **570** and **570***a*. The plurality of ribs **560**, **570** and **570***a* are connected to protrude from the inside of the corner. In addition, the plurality of ribs **560**, **570** and **570***a* are arranged to be spaced apart from each other. At least two side surfaces of a plate of each of the plurality of ribs **560**, **570** and **570***a* are connected to the side parts **521** and **522** at the corner.

FIG. **4**B is an oblique view of a rib shown in FIG. **4**A constructed as an embodiment in accordance with the principles of the present invention. Referring to FIG. **4**B, the first rib **560** is shaped of a plate. The plate has four outer surfaces **561**, **562**, **563** and **564**. The first outer surface **561** is connected to a portion of the first side part **521**. The second outer surface **562** is connected to a portion of the second side part **522**.

FIG. **4**C is an oblique view of a rib constructed as another embodiment in accordance with the principles of the present invention. As shown in FIG. **4**C, the second rib **570** may be formed to have an 'L' shape. The plate has four outer surfaces **571**, **572**, **573** and **574**. The second rib **570** is positioned above the first rib **560** and is connected to portions of the first side part **521** and the second side part **522**. The second rib **570** may protrude to the inside of first case **500** more than the first rib **560**. The second rib **570** may further include multiple second ribs formed toward the opened side of the first case **500**. In FIG. **4**A, reference numeral **570***a* refers to another second rib **570**, and a repeated explanation thereof will be omitted.

The first outer surface **571** and the second outer surface **572** are vertically bent to correspond to the inside of the corner of the first case **500**. The first outer surface **571** is connected to the first side part **521** and the second outer surface **572** is connected to the second side part **522**. A length **575** of the first outer surface **571** may be smaller than a length **578** of the second outer surface **572** adjacent thereto. In this case, the first case **500** may be shaped of a rectangular box having the first side part **521** shorter than the second side part **522**. In addition, the first outer surface **571** is longer than the third outer surface **573** formed at an end extending along the second outer surface **572**. In addition, a thickness **571***a* of the first outer surface **571** may be greater than a thickness **573***a* of the third outer surface **573**.

The second outer surface **572** may be longer than a first end **574***a* of the fourth outer surface **574** formed at an end extending along the third outer surface **573**. In addition, a thickness of the second outer surface **572** may be grater than that of the first end **574***a* of the fourth outer surface **574**.

The fourth outer surface **574** has a first end **574***a* bent and extending from one side of the first outer surface **571**, a second end **574***c* bent and extending from an end of the third outer surface **573** and a third end **574***b* connecting the first end **574***a* and the second end **574***c*. The first end **574***a* protrudes to the inside of first case **500** more than the third end **574***b*.

The second case **600** covers the opened side of the first case **500**. The second case **600** has a second planar part **610** and first to fourth side parts **621**, **622**, **623** and **624**. The first to fourth side parts **621**, **622**, **623** and **624** are bent from edges of the second planar part **610** and extend toward the first case **500**. A second case protection circuit module mounting portion **640** designed to correspond in shape to the protection circuit module **300** may be formed at one side of the second case **600** to cover the protection circuit module **300**. A second case connector mounting portion **641** in which the connector **330** of the protection circuit module **300** is mounted may be formed in the second case protection circuit module mounting portion **640**. The second case protection circuit module mounting portion **640** is located to correspond to the first case protection circuit module mounting portion **540**.

A sectional thickness **622**W of each of the first to fourth side parts **621**, **622**, **623** and **624** may be greater than a thickness **610**W of the first planar part **610**. Each of the first to fourth side parts **621**, **622**, **623** and **624** may include a second rib **630** having a plurality of coupling protrusions **630***a* located corresponding to the coupling grooves **530***a*, the coupling protrusions **630***a* engaged with the coupling grooves **530***a*. That is to say, the coupling protrusions **630***a* are formed on a second coupling surface of the second rib **630**.

Since four corners **601**, **602**, **603**, and **604** are formed in the second case **600** in the illustrated embodiment, second rib unit **650** is formed at the inside of each of the our corners. For

example, the corner **602** may be formed by connecting the first side part **621** and the second side part **622** to each other.

FIG. **5** is an enlarged oblique view of portion '**5***a*' in FIG. **3**, illustrating a second rib unit shown in FIG. **3** constructed as an embodiment in accordance with the principles of the present invention. As shown in FIG. **5**, the second rib unit **650** is located to correspond to the first rib unit **550**. The second rib unit **650** includes a plurality of ribs **660**, **670** and **670***a*. The plurality of ribs **660**, **670** and **670***a* are arranged to correspond to the ribs of the first rib unit **550**. Since shapes of the plurality of ribs **660**, **670** and **670***a* and connection mechanism in which the plurality of ribs **660**, **670** and **670***a* are connected to the corners of the second case **600** are the same as those of the plurality of ribs **560**, **570** and **570***a* of the first rib unit **550**, and repeated explanation thereof will be omitted.

The second case **600** may further include vertical ribs formed on at least one of the first to fourth side parts **621**, **622**, **623** and **624**. As shown in FIG. **5**, the second case **600** includes vertical ribs **691** and **692** formed on the second side part **622**. The vertical ribs further prevent the case from being deformed due to external shocks.

The case **400** has the first rib unit **550** and the second rib unit **650** respectively formed at the corners of the first case **500** and the second case **600**, thereby preventing the case **400** from being deformed due to external shocks, e.g., disconnection of connected parts.

Next, a first case **1500** and a second case **1600** of a battery pack constructed as another embodiment in accordance with the principles of the present invention will be described.

FIG. **6**A is an oblique view corresponding to FIG. **4**A, illustrating a third rib unit **1550** constructed as another embodiment of the present invention.

The third rib unit **1550** is formed at a corner of the first case **1500**. The third rib unit **1550** includes a plurality of ribs **560**, **570**, **570***a*, **580***a* and **580***b*. Each of the plurality of ribs **560**, **570** and **570***a*, **580***a*, **580***b* is connected to protrude from the inside of the corner. Since reference numerals **560**, **570** and **570***a* denoting the ribs are the same as described above in the first rib unit **550**, the same reference numerals are used to the same or similar parts and detailed descriptions thereof will be omitted.

The third rib unit **1550** further includes first reinforcement ribs **580***a* and **580***b* connecting at least two of the ribs. Referring to FIG. **6**A, at least three ribs **560**, **570** and **570***a* connecting the corners are connected to be spaced apart from each other. The reinforcement ribs **580***a* and **580***b* may be formed in multitude. The reinforcement rib **580***a* connects ends of the three ribs **560**, **570** and **570***a*. The reinforcement rib **580***b* vertically connects parts of the three ribs **560**, **570** and **570***a*. That is, the ribs **560**, **570** and **570***a* are horizontally disposed with respect to the first planar part **510** of the first case **500**, and the reinforcement ribs **580***a* and **580***b* are vertically disposed with respect to the ribs **560**, **570** and **570***a*. The reinforcement ribs **580***a* and **580***b* protrude from the inside of the second side part **522**. Since the third rib unit **1550** has multiple reinforcement ribs connecting the respective ribs **560**, **570** and **570***a* to each other, coupling forces between each of the ribs **560**, **570** and **570***a* can be reinforced.

FIG. **6**B is an oblique view corresponding to FIG. **5**, illustrating a fourth rib unit **1650** constructed as another embodiment of the present invention.

The fourth rib unit **1650** is formed at a corner of the second case **1600**. The fourth rib unit **1650** includes a plurality of ribs **660**, **670**, **670***a*, **670***b* and **680**. Each of the plurality of ribs **660**, **670**, **670***a*, **670***b* and **680** is connected to protrude from the inside of the corner. Since reference numerals **660**, **670**, **670***a* and **670***b* denoting the ribs are the same as described above in the second rib unit **650**, the same reference numerals are used to the same or similar parts and detailed descriptions thereof will be omitted.

The fourth rib unit **1650** further includes a second reinforcement rib **680** connecting at least two of the ribs. The second reinforcement rib **680** may be formed in multitude. The second reinforcement rib **680** reinforces coupling forces between each of the ribs of the fourth rib unit **1650**. The second reinforcement rib **680** may be positioned on an imaginary line along which the first reinforcement ribs **580***a* and **580***b* extend toward the second case **1600**.

As a result, since the first rib unit **1550** and the second rib unit **1650** are formed at the corners of the first case **1500** and the second case **1600** of the battery pack according to another embodiment invention, deformation due to external shocks, e.g., disconnection of connected parts, can be prevented.

Next, a first case **2500** and a second case **2600** of a battery pack constructed as still another embodiment in accordance with the principles of the present invention will be described.

FIG. **7**A is an oblique view corresponding to FIG. **4**A, illustrating a first case **2500** constructed as still another embodiment of the present invention.

The first case **2500** has corners formed by connecting neighboring ones of first to fourth side parts **521**, **522**, **523** and **524**. A plurality of ribs may be formed at the respective corners. The plurality of ribs may include a first rib unit **550** or a third rib unit **1550**. Since the first rib unit **550** and the third rib unit **1550** have previously been described with reference to FIGS. **4**A and **6**A, the same reference numerals are used to the same or similar parts and detailed descriptions thereof will be omitted.

The first case **2500** has a corner rib **590**R, i.e., a corner reinforcement unit, formed at a corner where the respective side parts are connected to each other. Since the corner rib **590**R increases a thickness of the corner, a strength of the corner can be increased.

FIG. **7**B is an oblique view corresponding to FIG. **5**, illustrating a second case **2600** constructed as still another embodiment of the present invention.

The second case **2600** has corners formed by connecting neighboring ones of first to fourth side parts **621**, **622**, **623** and **624**. A plurality of ribs may be formed at the respective corners. The plurality of ribs may include a second rib unit **650** or a fourth rib unit **1650**. Since the second rib unit **650** and the fourth rib unit **1650** have previously been described with reference to FIGS. **4**B and **6**B, the same reference numerals are used to the same or similar parts and detailed descriptions thereof will be omitted.

The second case **2600** has a corner rib **690**R formed at a corner where the respective side parts are connected to each other. Since the corner rib **690**R increases a thickness of the corner, a strength of the corner can be increased.

FIG. **8** is a photograph illustrating a test result of external shocks applied to a battery pack constructed in accordance with the principles of the present invention, and FIG. **9** is a photograph illustrating a test result of external shocks applied to a battery pack constructed in accordance with a Comparative Example.

The external shock test is conducted to determine whether the case **40** of the battery pack is deformed due to a falling shock. During the external shock test, the battery pack is dropped down to a concrete bottom at a height of 100 m. Table 1 shows external shock test result. To check whether connected parts of the case **40** are separated from each other or not.

TABLE 1

shock Test	Rib shape of first case corner	Rib shape of second case corner	Results of 10 tests
Experimental Example 1	First rib unit	Second rib unit	○
Experimental Example 2	Third rib unit	Fourth rib unit	○
Experimental Example 3	First rib unit + Reinforcement rib	Second rib unit + Reinforcement rib	○
Experimental Example 4	Third rib unit + Reinforcement rib	Fourth rib unit + Reinforcement rib	○
Experimental Example 5	First rib unit + side part thickness reinforcement	Second rib unit + side part thickness reinforcement	○
Experimental Example 6	third rib unit + side part thickness reinforcement	Fourth rib unit + side part thickness reinforcement	○
Comparative Example	No rib formed at corner of case	No rib formed at corner of case	X

(○: Not deformed; X: Deformed)

As shown in FIG. **8**, the external shock test results showed that the battery packs according to Experimental Examples 1 to 5 were not deformed, that is, connected parts of the case **400** were not separated from each other. In addition, no failures were found in the battery packs according to Experimental Examples 1 to 5 even after charge/discharge tests. In addition, defects due to falling shocks, e.g., a fire or electrolyte leakage, were not generated in the battery packs according to Experimental Examples 1 to 5.

According to the above described embodiment, a battery pack is provided with a case configured to prevent deformation by improving a coupling force against external shocks.

Although the present invention has been described with reference to certain exemplary embodiments thereof, it will be understood by those skilled in the art that a variety of modifications and variations may be made to the present invention without departing from the spirit or scope of the present invention defined in the appended claims, and their equivalents.

What is claimed is:

1. A battery pack, comprising:

a plurality of bare cells;

a circuit module electrically connected to the plurality of bare cells; and

a case accommodating the plurality of bare cells and the circuit module,

the case includes a first case having one side opened to accommodate the plurality of bare cells and the circuit module and a second case covering the opened one side of the first case,

the first case has a first planar part that is a bottom surface on which the plurality of bare cells are mounted, and first case side parts bent from the first planar part and extending toward the second case,

the first case has corners formed by connecting neighboring first case side parts, and

a first rib unit is formed at inside of at least one corner, the first rib unit comprising a plurality of longitudinally disposed ribs parallel to the first planar part, at least two of the longitudinally disposed ribs having a different shape from each other.

2. The battery pack of claim **1**, wherein the plurality of longitudinally disposed ribs are connected to and protrude from the inside of the corner, and each rib is arranged to be spaced apart from a neighboring rib.

3. The battery pack of claim **2**, wherein each of the longitudinally disposed ribs is shaped of a plate and at least two side surfaces of the plate are connected to the first case side parts at the corner.

4. The battery pack of claim **2**, wherein each of the longitudinally disposed ribs has a first outer surface and a second outer surface connected to the first case side parts at the corner, and the first outer surface and the second outer surface of at least one of the longitudinally disposed ribs have different lengths.

5. The battery pack of claim **2**, wherein at least one of the longitudinally disposed ribs is shaped of a plate having a thickness greater at one end than at the other end, and the thicker one end of the plate is connected to one of the first case side parts at the corner.

6. The battery pack of claim **2**, wherein the first rib unit further includes a first vertically disposed reinforcement rib connecting the at least two longitudinally disposed ribs.

7. The battery pack of claim **1**, wherein the first case further includes a corner reinforcement unit formed at the inside of at least one corner where the neighboring side parts are connected to each other.

8. The battery pack of claim **1**, wherein the second case has a second planar part corresponding to top portions of the mounted bare cells and second case side parts bent from the second planar part and extending toward the first case, the second case has corners formed by connecting neighboring second case side parts to each other, and a second rib unit is formed at inside of at least one corner of the second case.

9. The battery pack of claim **8**, wherein the second rib unit is located to correspond to the first rib unit.

10. The battery pack of claim **8**, wherein the second rib unit includes a plurality of longitudinally disposed ribs parallel to the second planar part, at least two of the longitudinally disposed ribs having a different shape from each other, each rib is shaped of a plate, and at least two surfaces of the plate are connected to and protrude from the inside of the corner.

11. The battery pack of claim **10**, wherein the ribs of the second rib unit are disposed to correspond to the ribs of the first rib unit.

12. The battery pack of claim **11**, wherein the second rib unit further includes a second vertically disposed reinforcement rib connecting at least two of the longitudinally disposed ribs.

13. The battery pack of claim **12**, wherein the second vertically disposed reinforcement rib is vertically aligned with a first vertically disposed reinforcement rib connecting the at least two longitudinally disposed ribs of the first rib unit.

14. The battery pack of claim **8**, wherein a sectional thickness of at least one of the second case side parts is greater than a thickness of the second planar part.

15. The battery pack of claim **1**, wherein a sectional thickness of at least one of the first case side parts is greater than a thickness of the first planar part.

16. The battery pack of claim **1**, wherein the first case has a plurality of coupling grooves formed in at least one of the first case side parts, and the second case has a plurality of coupling protrusions to be engaged with the coupling grooves.

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